on the Peace river," and "Note on a decapod Crustacean from the Upper Cretaceous of Highwood river, Alberta, N. W. T."

R. P. Whitfield contributes to *Science*, Vol. VI, p. 87, "An American Silurian scorpion." In the Bull. Amer. Mus. Nat. Hist., October 10, 1885, Vol. I, No. 6, pp. 181, 191 and 193, he has the following articles: "On a fossil scorpion from the Silurian rocks of America;" "Notice of a new Cephalopod from the Niagara rocks of Indiana;" "Notice of a very large species of Homalonotus from the Oriskany sandstone formation."

H. S. Williams, in the Proc. A. A. A. S., Vol. XXXIII, Part II, p. 422, publishes an article on "Geographical and physical conditions as modifying fossil faunas." In the *Amer. Jour. Sci.*, 3d ser., Vol. XXX, p. 45, he has a "Notice of a new limuloid Crustacean from the Devonian."

A. Winchell, in the *Amer. Jour. Sci.*, 3d ser., Vol. XXX, pp. 316 and 317, has "Notices of N. H. Winchell on Lingula and Paradoxides from the red quartzites of Minnesota," and "On Cœnostroma and Idiostroma and the comprehensive character of Stromatoporoids."

N. H. Winchell describes "Fossils from the red quartzites at Pipestone" in the Geol. and Nat. Hist. Surv. Minnesota, 13th Ann. Rep., p. 65.

H. H. Winwood, in the *Geol. Mag.*, new series, Decade III, Vol. II, p. 240, remarks on the "Geological age of the Rocky mountains;" in it he reports finding a Menevian fauna between the 116th and 117th parallels of longitude on the Canadian Pacific railway.

B. H. Wright, in the 35th Rep. N. Y. State Mus. Nat. Hist., p. 195, contributes "Notes on the geology of Yates county, N. Y."

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GRAVITATION AND THE SOARING BIRDS.

BY I. LANCASTER.

"IN experimental philosophy, all propositions collected by induction from phenomena are to be held either exactly or approximately true until other phenomena are found by which those propositions can be made either more accurate or subject to exceptions" (Newton's Principia, Book III).

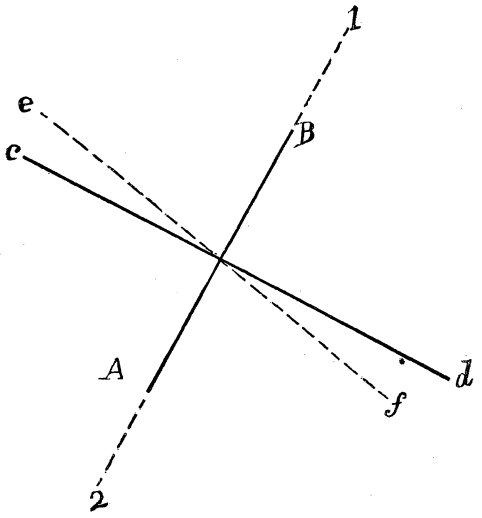
The soaring birds seem to be excused from obedience to the laws determining the actions of other inert bodies heavier than

the air, which are abandoned to its support. Weighing more than the air they displace, and using no muscular exertion to sustain themselves, they still, in the sense of getting nearer to the earth, do not fall. When we seek for a motive power which is competent to resist the weight of the bird's body, and neutralize the resistance of the air to its translation, we seem baffled. Bird and air form a material system in which no other object is included, so that it is impossible to obtain power from the wind. Wind is motion of the entire system as a whole, compared to a fixed object, as an observer, and such motion does not affect the motion of the parts. Wind from any direction, or at any velocity, or entire calm are differences of air-conditions to an observer, but not to a bird. We are therefore limited to the gravitating force of the bird's body to find the power producing the phenomena, as it is nowhere else discoverable. But here we are confined to certain notions derived from sticks and stones, and in fact all other falling things, and they do not seem to help us in explaining a thing which does not fall. We are likewise taught that the direction of the gravitating force is vertically downwards, *i. e.*, in a straight line from the body manifesting it to the center of the earth. What we understand by this "direction" is, that when gravity does work, when it is in the act of making anything different from what it was before, when it moves a thing at rest, or stops it when in motion, or accelerates it, or is in the act of manifesting energy in the way which we call "work," that the "direction" in which it does it is vertically downwards. How then can this force drive a body upwards, or translate it horizontally?

Still further. Although we admit, when our attention is called to it, that weight is the result of gravity acting on a quantity of matter, we are apt to confound mass, and weight, and gravity into one identical thing. This is inadmissible, since the doctrine of the correlation of forces is established, as it is entirely possible to change every atom of gravitating force which a body manifests into some other form of force, in which case either the former is separate from the quantity of matter or the latter is created. We thus find ourselves in a sort of dilemma. We are obliged to consider gravity as something apart from body, and still we have no knowledge of it excepting what we are enabled to infer about it. Were it not for these inferences we would be shut up to the conclusion that the quantity of matter was acting, and that grav-

ity, as a separate force, was simply non-existent, for it never manifests its power but in connection with body, and the action of the body is our rule to determine the action of the force.

It would be expected that in dealing with agencies of this kind, the greatest care should be exercised lest we fall into errors, and it is apparent that many of our notions in regard to gravitating bodies have been brought up from generalizations which do not include all the facts. The soaring birds have been omitted. To the extent of their exclusion our ideas are subject to error. It is imperative that they be brought under the dominion of gravity, and that the phenomena presented by them shall have due recognition in determining the characteristics of that force.



I have shown in the pages of this magazine that these birds can be reduced to lower terms. A plane resting in air, and acted on by a force, exhibits all their activities, and up to this time, so far as my knowledge extends, the mechanical world has failed to recognize the facts exhibited by such a body, when subjected to work on elastic air.

To accomplish my purpose most directly, it will be best to touch upon ground already covered, and I will do so in the following propositions, which are self-evident on statement. Unless otherwise noted, acceleration will be supposed to have terminated and uniform motion progressing.

As there is no authority for the value of frictional resistance of air on smooth surfaces, and as I have failed to measure it by any experimental test at my command, on account of its extreme smallness, the argument would be in no wise affected if it were not taken into account for any of the velocities that we shall deal with. The reader may therefore place upon it any value within reasonable limits.

Let *A B* represent one of the edges of a plane, say one foot square, resting in air, and of the same weight as the atmosphere it displaces.

1. The only actual or conceivable work the plane can be subject to under the dominion of any force whatever, is either air pressure upon its sides, or resistance to atmospheric surface or skin friction, parallel to itself or in its own plane.

2. From the law of fluid pressures, and the contrary and equal character of action and reaction, a force operative upon the plane *A B* from any direction, does work in one, or both, of two ways, viz., either in it or at right angles to it.

3. Forces in the direction of *c d*, or in the plane in any direction, are not resolved by the plane, but work to their full value in absolute independence of each other, as they are right-angled forces.

4. Forces from any direction, excepting in the plane and normal to it, are resolved by the plane into those two directions.

5. Any number of forces, not in the plane nor normal to it, operate upon it in the resultant of one force, from one direction; and this resultant, if not already in the plane or normal to it, is resolved therein by the plane.

6. It follows that the plane can be subject to work only, (1) in its own plane, (2) in a direction at right angles to its surfaces, (3) in both of these directions.

7. The nature of the work done by the force acting normal to the plane is compressing air, and as the resistance of the atmosphere to motion in this direction is very great, the velocity will be correspondingly slow.

8. The nature of the work done by the force in the plane, is overcoming atmospheric friction on the two surfaces, which being very little, motion in this direction will be correspondingly great.

9. A force not in the plane, nor normal to it, is resolved by the

plane into those forces in the same ratio that the direction of the force bears to those directions.

To illustrate these propositions we will suppose a force, *e f*, inclined 18° from *c d*, to operate on the plane *A B*, with a value of sixty foot pounds per second. The plane would instantly resolve this force into twelve foot pounds in its own plane in the direction 2, and forty-eight foot pounds in the direction *c d*, at right angles to it, when it would be reasonable to suppose that the twelve pounds would drive the plane against friction of air with far greater velocity than forty-eight pounds would against air compression.

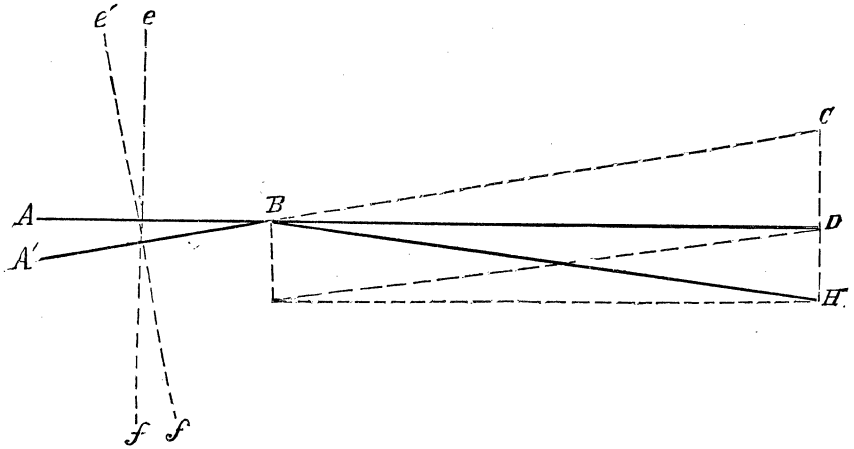
If motion in the direction 2 were resisted to the point of prevention, all the force, *e f*, would do work in the direction *c d*, when the entire sixty pounds would be setting up air pressure, and the plane would be in equilibrium in the direction 1 2. A very small force, say one or two pounds, would now drive the plane in any direction, say towards 1, with considerable velocity.

It is obvious that the sixty pounds of air pressure would be enough to supply the twelve pounds needed to balance the force acting towards 2, and the one or two pounds additional needed to drive the plane towards 1 with a velocity we will suppose of 150 feet per second. If we suppose the motion of the plane in the direction *e f* to be at the rate of thirty feet per second, it will move in opposition to the direction of the force as fast as it does with its direction, and we will have the anomalous case of a force developing enough force in moving a body to move several such bodies through the same space in the same time diametrically opposite to its own direction!

This seems absurd, and needs rectification to make it tolerable. We have entirely overlooked the fact that the moment *e f* began the task of working it abandoned the direction in which it resided, and four-fifths of it went over 18° to *c d*, and one-fifth went over 108° to *A B*. The direction *e f* is vacated, it is without significance. For all the influence it has on the plane it might as well not exist. There is *now* no movement of the plane against the direction of the force whatever. *Now*, the forces working on air, and driving the plane towards 1, are at right angles to each other and do not resist each other. The problem is, the ability of a force to drive a plane faster edgeways than flatways through air.

In going over, the one-fifth that traveled 108° was wasted, *i. e.*, it neutralizes an equal amount of the other, so that only forty-eight pounds, instead of sixty pounds, are available to drive the plane edgeways; but this would be competent to produce an enormous velocity. Had the force been originally in *c d*, the entire sixty pounds would have been available.

But when we rectify the diagram so as to make *e f* vertical, and add two pounds weight to the plane, so that the force employed will be gravity, all the ghosts, which we supposed laid, at once reappear in vastly magnified proportions. The outcry now is, that the law of falling bodies is violated, for a body in falling can do no more work than sufficient to lift it through the same



perpendicular height. It seems that here is a good place to establish an exception, and we will examine into the way in which it may be done.

While the plane *A B* is level, the gravitating force is not resolved by it, but acts at right angles to the surfaces, when lateral motion will be resisted by nothing but atmospheric friction, and this the one or two pounds is competent to overcome, driving the plane to *D* while it is falling the thirty feet in which the sixty pounds is developed. It will therefore pass to *H*, the resultant of the two motions. It will simply have a lateral motion of 150 feet edgeways through the air added to its fall of thirty feet. To its work of air compression there will be joined an additional item of work in overcoming 150 feet of atmospheric friction. The

force developed in the fall will be enough to supply the lateral force and still leave fifty-eight or fifty-nine pounds to go to waste by falling to the tension of the surrounding air.

But this would not be "soaring," as the plane will soon reach the ground.

If we now throw the plane over on an incline of one in five, or 18°, we have an additional twelve pounds of lateral resistance to overcome, which the sixty pounds is entirely competent to effect, together with the one or two needed to carry the plane to *c*, and still have forty-six or forty-seven pounds more than is wanted left over. We now have the plane elevated as fast as it falls, so that its resultant passage to *D* is the horizontal translation of flight, and a body in falling does work enough to not only lift it to the same height from which it fell, but to move it against air resistance, and have a large surplus left over!

This seems impossible. But the reason of such appearance, as already shown, is that we are entertaining a fallacy. We are supposing the direction of the gravitating force to still be vertical after it has gone over eighteen and a hundred and eight degrees. We have, as a matter of fact, changed the direction of gravity more than we have slanted the plane. One-fifth of its total amount has gone over 108°. The plane has taken the same liberty with the great cosmical force of gravitation that it would with any other force. It refuses to be operated upon by any energy whatever of a mechanical kind while doing work on elastic fluids, excepting in the two directions mentioned, and any force whatever, not in either of these, is instantly put there by the plane. To say that the gravitating force is still vertical, and has not gone over, is to increase the difficulties of the case and not to abate them. In such event the law of fluid pressures is violated, which demands that they be at right angles to the compressing surface. The plane would also fall vertically without lateral motion, all of which is impossible. *Some* force is actuating *A′ B* in its own plane and normal to it. From whence comes it? There is but one source of supply. The plane has simply resolved gravity until its perpendicular line has been vacated, and re-located at right angles to the lateral force acting in the plane, which lifts no weight, and resists nothing whatever but friction. The plane, in its translation towards *c*, is moving towards *e*, but not towards *e′*. It is going contrary to the abstract

direction of gravity, but not contrary to the direction in which that force is now working, which alone concerns us.

The whole matter hinges on the ability of a plane to resolve the gravitating force as it resolves other forces. In doing so it does a very wonderful thing. It makes of gravity a continuous motive power. It introduces a new idea into our conceptions of things, and makes it imperative that we rectify our notions of the gravitating force so as to admit these facts, which we have not hitherto recognized.

It dignifies the soaring birds into the position of favored creatures of nature. They inhabit a universe of their own. The horizon of their world is not the level of the sea, but the incline of their own wings, which they can change at will. Their gravitating force is either in a straight line from their bodies towards the center of the earth, or the moon, or the sun, or any of the stars of heaven, indifferently, as it suits them, to sleep on the breeze, to play at gymnastics high in air, to enact the rôle of the highway robber, or to serenely float from zone to zone.

I have now presented the case of the soaring birds to the extent of my ability. The task could have been better done by a specialist in analytic mechanics, as it is in this sphere that its significance lies. The whole matter is extremely peculiar. In consequence of the throng of preconceived ideas which tend to cast the obscurity of night over the whole case, the evidence upon which it rests, although axiomatic throughout, is difficult to see. The mechanism also seems devoid of organization, a simple plane is all there is of it, and still it has the power to change the horizon of the world to suit its own purposes. It would be unwise to suppose that a device capable of doing this was not competent to give to man what he has long coveted, the power to navigate the air.

Certainly we must entertain two standards of horizontal, one the level of the sea, and the other the incline of the wings of the soaring birds.

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CAUSES OF FOREST ROTATION.

BY JOHN T. CAMPBELL.

IN a letter recently received from Dr. S. V. Clevenger, he mentioned a case coming under his own observation on the North Pacific railroad, in Minnesota, near Mille Lacs, where the railroad